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㉒ 参 考 文 献 実開 昭61-35418 (J P, U)

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㉓ 実用新案登録請求の範囲

送信時は発振回路に直接周波数変調信号を加えて変調し、受信時は発振周波数をシフトする電圧制御発振器の周波数変調回路において、電圧制御発振器の電圧制御可変容量ダイオードを含む発振同調回路にコンデンサを接続し、該コンデンサの他端にはスイッチングダイオードのアノードを接続し、該スイッチングダイオードのカソードはエミッタ接地スイッチングトランジスタのコレクタと接続し、前記スイッチングダイオードのアノード並びにスイッチングトランジスタのベースに受信時は正電圧を供給する回路を接続して前記コンデンサを接地する発振周波数シフト手段と、前記スイッチングダイオードのカソードに変調信号と逆バイアス電圧を送信時に供給する回路を接続し、送信時に前記スイッチングダイオードを遮断して発振周波数を変調する周波数変調手段とに、前記電圧制御可変容量ダイオードの制御電圧回路と逆バイアス回路間に抵抗を接続して制御電圧と逆バイアス電圧の相乗効果で周波数変調の偏移量を安定化させる偏移量安定手段を付加したことを特徴とする電圧制御発振器の周波数変調回路。

考案の詳細な説明

〔産業上の利用分野〕

本考案は携帯形通信機のごとき比較的容易な構成の周波数変調（以下、FMと略記する）トランシーバに用いて好適な周波数変調回路に関するも

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のである。

〔従来の技術〕

FM送信機やMFトランシーバの送信時の変調方法としては、中形以上の据置機では水晶制御の原発振器によりFM波を作り、通倍を重ねて必要な送信電波を得ているが、装置が複雑大形となるので小型簡便を旨とする携帯形のFMトランシーバでは自励発振器の発振同調回路に電圧制御容量ダイオードを用いて、更に、バイアス電圧に変調信号を重ねることにより、FM波を発生させていたが、安定度が悪い欠点があった。

〔考案が解決しようとする課題〕

簡易なFMトランシーバの構成例として第2図に示すように受信部はスーパーヘテロダイン方式のミキサ段に注入する局部発振器にPLL制御のVCOを用い、周波数安定度と周波数精度の良い選局動作を行い、送信時には前記VCOに変調信号を加えて直接に送信周波数のFM波を作り、これを電力増幅してアンテナに送出するのであつて、無駄の無い構成である。この回路において受信周波数と局部発振周波数とは中間周波数だけの差があるので、受信と送信を同一周波数で行うためには、送信時にFMの原発振器となるVCOの発振周波数を中間周波数分だけずらして受信周波数と同一にする必要がある。

上記目的に使用されるVCO回路例を第3図に示す。図において同調コイル31と電圧制御容量

ダイオード32は負抵抗回路と組合わせて発振回路を形成し、電圧制御容量ダイオード32にPLL回路より制御電圧12を加えて発振周波数を所定値にロックする。FM受信機の間周波数は10.7MHzが標準であり、局部発振周波数は発振の楽な低い方を取るのが普通であるからVCO周波数を送信時には受信時より10.7MHz低下させるにあたってコンデンサ33を送信時に発振同調回路から切り離すために送信、受信の周波数の切替を行う場合、送受両方の回路に兼用できバイアス電圧によってスイッチの作用を持たせることができるスイッチングダイオード34を用いて、同調用コイル31および電圧制御容量ダイオード32からなる発振用共振回路にコンデンサ33を並列に接続し、コンデンサ33を回路に挿入、又は回路を遮断できるようにスイッチングダイオード34を直列にして接地し、受信時には、スイッチングダイオード34を導通してコンデンサ33を回路に挿入し、送信時にはスイッチングダイオード34に逆バイアス10を加えて、スイッチングダイオード34の片側の電圧を高くしてカットオフ状態とするが、その際のスイッチングダイオード34の電極間静電容量は数pFであり、かつ逆バイアス電圧値により静電容量値も変化する性質があるから逆バイアス電圧10に変調信号11を重畳することによりFM波が得られるものである。

現在の通信用には±10KHz以上の小偏移FMが使用されているのでスイッチングダイオード34の容量変化によるFMで間に合うことが多いが、偏移量が不足の場合には電圧制御容量ダイオードを使用すればよい。

第3図の回路方式では、周波数偏移量を問題とする場合、出力の平均値をとって発振強度を揃えるために、制御電圧12は幅広くとって測定するのであるが、この制御電圧12を大きくした場合には、電圧制御容量ダイオード32の容量は減少するので、スイッチングダイオード34を変調用ダイオードに共用した場合容量変化による周波数偏移量は大きく、制御電圧12を小さくした場合には電圧制御ダイオード32の容量は増大するので、変調用ダイオードの容量変化が同一でも周波数偏移量は小さくなるという事がある。

この周波数偏移量の変化の対策の従来例として

は第4図のように変調信号回路に電圧制御可変利得増幅器を入れて、これに前記制御電圧12を加えることにより、周波数偏移量を一定に保とうとする方法や第5図のように電圧制御容量ダイオード32とほぼ同様の電圧制御容量ダイオード35を追加して、これに変調信号11と同時に抵抗36を通して制御電圧12を加えることにより、この制御電圧12の変化に伴う周波数偏移量の変化を自動的に補正する方法等があるが、いずれも部品の追加や回路の増加を伴うのであつて、折角スイッチングダイオード34を変調用にも共用して回路構成を簡略化した目的に反する結果となつており、もつと簡易な補正方法が望まれていたものである。

〔課題を解決するための手段〕

電圧制御可変容量ダイオードを含む発振同調回路にコンデンサを接続し、前記コンデンサの他端にはスイッチングダイオードのアノードを接続し、前記スイッチングダイオードのカソードはエミッタ接地スイッチングトランジスタのコレクタと接続し、前記スイッチングダイオードのアノード並びにスイッチングトランジスタのベースに受信時は正電圧を供給する回路を接続して前記コンデンサを接地する発振周波数シフト手段と、前記スイッチングダイオードのカソードに変調信号と逆バイアス電圧を送信時に供給する回路を接続し、送信時に前記スイッチングダイオードを遮断して発振周波数を変調する周波数変調手段とに、前記電圧制御可変容量ダイオード含む発振同調回路と逆バイアス回路間に抵抗を接続して制御電圧と逆バイアス電圧との相乗効果で周波数変調の偏移量を安定化させる偏移量安定化手段を付加した構成である。

〔実施例〕

第1図は本考案の概要図である。この回路は、第2図に示す送・受信回路の局部発振器に関するもので受信と送信とで異なる周波数で発振し、かつ送信時は発振器で直接周波数変調を行うものである。

第1図中、1は同調コイル、2は電圧制御可変容量ダイオードで制御電圧12によって発振周波数が可変される。3はコンデンサで受信時に発振周波数をシフトさせるコンデンサであり、受信時に順方向バイアス13を加えて送信、受信の両方

の回路に兼用できバイアス電圧によつてスイッチの作用を持つスイッチングダイオード4を導通させることで発振回路にコンデンサ3が付加される。スイッチングダイオード4は送信時は非導通となるように逆バイアス10が供給され更に、この逆バイアス10には変調信号11が重畳されて、スイッチングダイオード4を介して供給し周波数変調される。

以上の構成の回路に逆バイアス10と電圧制御可変容量ダイオード2を制御する発振同調回路との間に抵抗を接続して、変調素子として動作するスイッチングダイオード4にも制御電圧12の変化の影響がでるようにして、電圧制御容量ダイオード2に加える制御電圧12の大小に伴う周波数偏移量の変化を軽減する構成である。

実際の回路は第6図に示す実施例の構成である。第6図と第1図の同一符号部分は同一部品である。負抵抗回路部分はFETを用いたコルピツツ回路構成である。スイッチングトランジスタ6は送信時にはベースにスイッチングダイオード4と共通に順バイアスを加えてコレクタ・エミッタ間を導通することによりスイッチングダイオード4の帰路となり、送信時にはベースはゼロバイアスとなるのでコレクタ・エミッタ間は開放状態となり、変調信号11と抵抗7を通した逆バイアス10とがスイッチングダイオード4のカソード側に加えられて周波数変調を行うのであるが、この回路には抵抗5を通して制御電圧12を加えることにより、この制御電圧12の変化に伴うFM波の周波数偏移量の変化を軽減している。

第6図に記入の回路定数での実測において、制御電圧12を2.5Vで発振周波数を152MHzに設定した場合に、制御電圧12が1Vで発振周波数は約140MHz、制御電圧12が4Vで発振周波数は約162MHzであり、制御電圧12が2.5Vの時にFMの周波数偏移が $\pm 3.5\text{kHz}$ となるように変調信号11のレベルを設定し、制御電圧12のみを2Vと4V

に変えた場合の周波数偏移はそれぞれ $\pm 3.2\text{kHz}$ と $\pm 3.3\text{kHz}$ であつて、最大偏差は $\pm 0.3\text{kHz}$ であり10%以下であつた。比較のため第6図回路より抵抗5を除いた従来回路での結果を示せば、制御電圧12の1Vと4Vにおいて周波数偏移はそれぞれ $\pm 2.6\text{kHz}$ と $\pm 3.9\text{kHz}$ であつて、最大偏差は $\pm 1.3\text{kHz}$ となり約37%の変化率となつたのである。

上記結果をグラフで示したのが第7図であつて、本考案回路の結果は実線Aで、従来回路での結果は点線Bで示してあり、本考案回路での効果は明らかである。

〔考案の効果〕

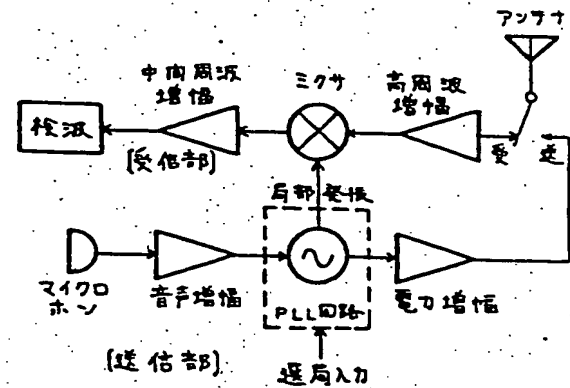
本考案は、従来の周波数変調回路の回路構成に抵抗を1個追加するだけの極めて簡単な改良により、制御電圧の変化に伴うFM波の周波数偏移量の変化を安定し得る効果のあることは前記本考案の実施例における第7図の実測結果により明らかである。

図面の簡単な説明

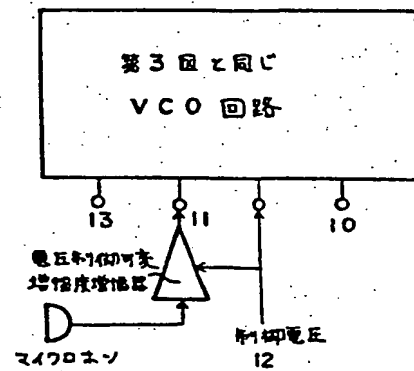
第1図は本考案の周波数変調回路の概要図、第2図は携帯形等の簡易構成のFMトランシーバーの回路構成図、第3図は第2図中の局部発振器兼FM変調器に適当な周波数変調回路の例、第4図第5図は第3図回路における制御電圧の変化に伴う周波数偏移量の変動を補正した周波数変調回路の例、第6図は本考案の実施例、第7図は第6図の本考案実施回路の制御電圧対周波数偏移量の実測値と、本考案を適用しない従来回路での制御電圧対周波数偏移量の実測値を表示するグラフである。

1, 31……同調コイル、2, 32, 35……電圧制御可変容量ダイオード、3, 33……コンデンサ、4, 34……スイッチングダイオード、5, 7, 35……抵抗器、6……スイッチングトランジスタ、10……逆バイアス、11……変調信号、12……制御電圧、13……順方向バイアス。

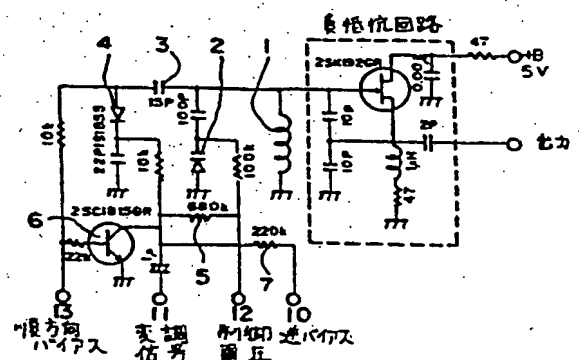
第2図



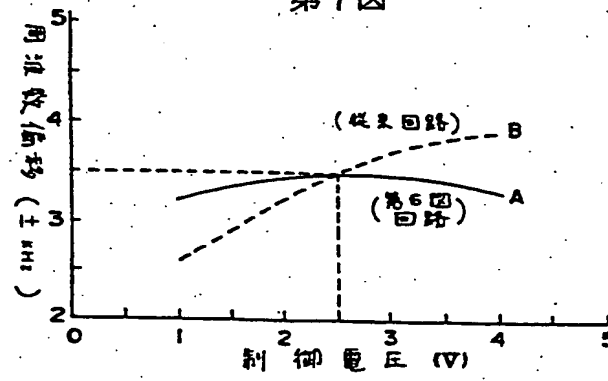
第4図



第 6 図



第7図



Full Translation

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Title of the Invention: Frequency modulation circuit

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Applicant: Yaesu Musen Co., Ltd.

[Claim]

A frequency modulation circuit suitable for a voltage-controlled oscillator, for directly applying a frequency modulation signal to an oscillation circuit and modulating the same upon transmission and shifting an oscillation frequency upon reception, characterized in that amount-of-shift stabilizing means for connecting a resistor between a control voltage circuit for a voltage-controlled variable capacitance diode and a reverse bias circuit to thereby stabilize the amount of shift of frequency modulation with a synergistic effect of a control voltage and a reverse bias voltage is added to oscillation frequency shift means for connecting a condenser to an oscillation tuning circuit including the voltage-controlled variable capacitance diode of the voltage-controlled oscillator, connecting an anode of a switching diode to the other end of the condenser, connecting a cathode of the switching diode to a collector of a common-emitter switching transistor, and

connecting a circuit for supplying a positive voltage upon reception to the anode of the switching diode and a base of the switching transistor to thereby ground the condenser, and frequency modulating means for connecting a circuit for supplying a modulated signal and the reverse bias voltage upon transmission to the cathode of the switching diode and cutting off the switching diode upon transmission to thereby modulate an oscillation frequency.

Detailed Description of the Invention

[Industrial Field of Application]

This invention relates to a frequency modulation circuit suitable for use in a frequency modulated (hereinafter abbreviated as "FM") transceiver having a relatively simple configuration, like a portable communication device.

[Prior Art]

A method of performing modulation upon transmission of an FM transmitter or an FM transceiver was accompanied by a drawback in that although in a stationary device of middle or more size, an FM wave was produced by a crystal-controlled original oscillator and over-multiplied to thereby obtain a necessary transmit radio wave, the device became complex and large-sized, whereas although in a portable FM transceiver aiming at obtaining a small size and simplicity, a voltage-controlled capacitance diode was used in an oscillation tuning

circuit of a self-excited oscillator and a modulated signal was superimposed on a bias voltage to thereby generate an FM wave, stability was poor.

[Problems that the Invention is to Solve]

As a configuration example of a simple FM transceiver, there is provided a useless-free configuration wherein as shown in Fig. 2, a receiving unit makes use of a PLL-controlled VCO as a local oscillator inserted into a mixer stage of a superheterodyne system to perform a channel select operation good in frequency stability and frequency accuracy, and a modulated signal is added to the VCO upon transmission to directly produce an FM wave having a transmit frequency, which is then power-amplified, followed by delivery to an antenna. Since a difference corresponding to an intermediate frequency alone exists between a receive frequency and a local oscillation frequency in such a circuit, there is a need to shift an oscillation frequency of a VCO used as an FM's original oscillator by the intermediate frequency upon transmission to thereby allow the oscillation frequency to be identical to the receive frequency in order to perform reception and transmission with the same frequency.

An example of a VCO circuit used for the above purpose is shown in Fig. 3. In the drawing, a tuning coil 31 and a voltage-controlled capacitance diode 32 form an

oscillation circuit in combination with a negative resistance circuit. A control voltage 12 is applied to the voltage-controlled capacitance diode 32 from a PLL circuit to lock an oscillation frequency of the oscillation circuit to a predetermined value. An intermediate frequency of an FM receiver is 10.7MHz as a standard and a local oscillation frequency usually assumes a low one easy to oscillate. Therefore, when switching is made between transmit and receive frequencies to disconnect a condenser 33 from an oscillation tuning circuit upon transmission when a VCO frequency is set lower by 10.7MHz than at reception upon transmission, the condenser 33 is parallel-connected to the oscillation resonance circuit comprised of the tuning coil 31 and the voltage-controlled capacitance diode 32 through the use of a switching diode 34 which can be shared for both transmitting and receiving circuits and allowed to have switch action according to a bias voltage, and the switching diode 34 is grounded in series so as to be capable of inserting the condenser 33 into the corresponding circuit or cutting off the circuit. Upon reception, the switching diode 34 is brought into conduction to insert the condenser 33 into the circuit. Upon transmission, a reverse bias 10 is applied to the switching diode 34 to increase the voltage on the one side of the switching diode 34, thereby bringing about its cut-off state. Since, however, the interelectrode

electrostatic capacitance of the switching diode 34 is a few pF, and the switching diode 34 has such a property that its electrostatic capacitance value also changes according to a reverse bias voltage value, a modulated signal 11 is superimposed on the reverse bias voltage 10 to thereby obtain an FM wave.

Since a small shift FM of $\pm 10\text{KHz}$ or more is used for the present communications, FM based on a change in the capacitance of the switching diode 34 will suffice in most cases. However, when the amount of frequency shift is insufficient, the voltage-controlled capacitance diode may be used.

In the circuit system of Fig. 3, the control voltage 12 is measured with its width as wide to take an average value of outputs and thereby uniform oscillation intensities where the amount of frequency shift is handled as a problem. Since, however, the capacitance of the voltage-controlled capacitance diode 32 decreases when the control voltage 12 is set high, the amount of frequency shift based on a change in capacitance increases when the switching diode 34 is shared for a modulating diode. Since the capacitance of the voltage-controlled diode 32 increases when the control voltage 12 is set low, the amount of frequency shift might be reduced even if a change in the capacitance of the modulating diode is uniform.

As conventional examples of taking countermeasures

against such a change in the amount of frequency shift, may be mentioned, a method of inserting a voltage-controlled variable gain amplifier into a modulation signal circuit and applying the control voltage 12 thereto to thereby keep constant the amount of frequency shift as shown in Fig. 4, a method of additionally providing a voltage-controlled capacitance diode 35 substantially similar to the voltage-controlled capacitance diode 32 and applying a control voltage 12 thereto through a resistor 36 simultaneously with a modulated signal 11 to thereby automatically correct a change in the amount of frequency shift with a change in the control voltage 12 as shown in Fig. 5, etc. However, any is accompanied with the addition of parts and a circuit increase. Therefore, this brings about a result unfit for the precious purpose of sharing the switching diode 34 even for modulation to thereby simplify a circuit configuration. Thus, a simpler correcting method has been desired.

[Means for Solving the Problems]

A configuration is provided wherein amount-of-shift stabilizing means for connecting a resistor between an oscillation tuning circuit including a voltage-controlled variable capacitance diode and a reverse bias circuit to thereby stabilize the amount of shift of frequency modulation with a synergistic effect of a control voltage and a reverse bias voltage is added to oscillation

frequency shift means for connecting a condenser to the oscillation tuning circuit including the voltage-controlled variable capacitance diode, connecting an anode of a switching diode to the other end of the condenser, connecting a cathode of the switching diode to a collector of a common-emitter switching transistor, and connecting a circuit for supplying a positive voltage upon reception to the anode of the switching diode and a base of the switching transistor to thereby ground the condenser, and frequency modulating means for connecting a circuit for supplying a modulated signal and the reverse bias voltage upon transmission to the cathode of the switching diode and cutting off the switching diode upon transmission to thereby modulate an oscillation frequency.

[Embodiments]

Fig. 1 is a schematic diagram of the present invention. This circuit relates to the local oscillator for the transmitting/receiving circuits shown in Fig. 2, which oscillates at the frequencies different from each other upon reception and transmission and performs direct frequency modulation with the corresponding oscillator upon transmission.

In Fig. 1, reference numeral 1 indicates a tuning coil, and reference numeral 2 indicates a voltage-controlled variable capacitance diode whose oscillation frequency is varied according to a control voltage 12.

Reference numeral 3 indicates a condenser, i.e., a condenser for shifting the oscillation frequency upon reception. Upon reception, a forward bias 13 is applied to bring into conduction, a switching diode 4 which can be shared for both transmitting and receiving circuits and has switch action according to a bias voltage, whereby the condenser 3 is added or connected to an oscillation circuit. The switching diode 4 is supplied with a reverse bias 10 so as to bring into non-conduction upon transmission. Further, a modulated signal 11 is superimposed on the reverse bias 10, which in turn is supplied via the switching diode 4 and frequency-modulated.

The circuit having the above-described construction takes a configuration wherein resistors are connected between the reverse bias 10 and an oscillation tuning circuit for controlling the voltage-controlled variable capacitance diode 2 to exert an influence of a change in the control voltage 12 even on the switching diode 4 operated as a modulation element, thereby reducing a change in the amount of frequency shift with the magnitude of the control voltage 12 applied to the voltage-controlled capacitance diode 2.

An actual circuit takes a configuration of an embodiment shown in Fig. 6. Portions identified by the same reference numerals in Fig. 6 and Fig. 1 are the same parts respectively. A negative resistance circuit portion

is a Colpitts circuit configuration using FET. A forward bias is applied to the base of a switching transistor 6 in common with a switching diode 4 upon transmission to bring conduction between the collector and emitter thereof, so that the switching transistor 6 assumes a return path of the switching diode 4. Since the base is brought to a zero bias upon transmission, an open state is formed between the collector and emitter, so that a modulated signal 11 and a reverse bias 10 inputted via a resistor 7 are applied to the cathode side of the switching diode 4 to thereby perform frequency modulation. On the other hand, a control voltage 12 is applied to this circuit via a resistor 5 to thereby reduce a change in the amount of frequency shift of an FM wave with a change in the control voltage 12.

When the control voltage 12 is set to 2.5V and the oscillation frequency is set to 152MHz upon actual measurements at circuit constants described in Fig. 6, the level of the modulated signal 11 is set in such a manner that the oscillation frequency takes about 140MHz when the control voltage 12 is 1V, the oscillation frequency assumes about 162MHz when the control voltage 12 is 4V, and the frequency shift of FM reaches $\pm 3.5\text{kHz}$ when the control voltage 12 is 2.5V. Frequency shifts obtained when only the control voltage 12 was changed to 2V and 4V, were respectively $\pm 3.2\text{kHz}$ and $\pm 3.3\text{kHz}$, and the maximum deviation was $\pm 0.3\text{kHz}$, thus resulting in 10% or

less. If the result obtained by the conventional circuit in which the resistor 5 is removed from the circuit of Fig. 6 is shown for comparison, then frequency shifts obtained when the control voltage 12 was set to 1V and 4V, were respectively $\pm 2.6\text{kHz}$ and $\pm 3.9\text{kHz}$, and the maximum deviation was taken as $\pm 1.3\text{kHz}$, thus resulting in a rate of change corresponding to about 37%.

Fig. 7 shows the above results in the form of a graph. The result obtained by the circuit according to the present invention is indicated by a solid line A, and the result obtained by the conventional circuit is indicated by a dotted line B. An effect obtained by the circuit according to the present invention becomes apparent.

[Advantage of the Invention]

According to the present invention, the advantage of making it possible to stabilize a change in the amount of frequency shift of an FM wave with a change in control voltage by virtue of a simplest improvement in the addition of only one resistor to a circuit configuration of a conventional frequency modulation circuit becomes apparent from the actually-measured result of Fig. 7 obtained in the embodiment of the present invention.

Brief Description of the Drawings

Fig. 1 is a schematic diagram of a frequency modulation circuit of the present invention; Fig. 2 is a circuit configuration diagram of a simple-configured FM

transceiver such as a portable type or the like; Fig. 3 shows an example of a frequency modulation circuit suitable for a local oscillator-cum-FM modulator in Fig. 2; Figs. 4 and 5 respectively show examples each illustrative of a frequency modulation circuit in which a change in the amount of frequency shift with a change in control voltage in the circuit shown in Fig. 3 is corrected; Fig. 6 shows an embodiment of the present invention; and Fig. 7 is a graph indicating actually-measured values of control voltage vs. amount-of-frequency shift in the circuit according to the embodiment of the present invention, which is shown in Fig. 6, and actually-measured values of control voltage vs. amount-of-frequency shift in a conventional circuit to which no present invention is applied.

1, 31 tuning coils, 2, 32, 35 voltage-controlled variable capacitance diodes, 3, 33 condensers, 4, 34 switching diodes, 5, 7, 35 resistors, 6 switching transistor, 10 reverse bias, 11 modulated signal, 12 control voltage, 13 forward bias.

* * * * *

[Figure 1]

10 ... reverse bias, 11 ... modulated signal, 12 ...
control voltage, 13 ... forward bias
negative resistance circuit

[Figure 2]

detector, intermediate frequency amplifier, mixer,
high frequency amplifier, receive, transmit, antenna
[receiving unit]
microphone, voice amplifier, local oscillation, PLL
circuit, a channel select input, power amplifier
[transmitting unit]

[Figure 3]

10 ... reverse bias, 11 ... modulated signal, 12 ...
control voltage, 13 ... forward bias
negative resistance circuit

[Figure 4]

VCO circuit identical to Fig. 3
voltage-controlled variable amplification-factor
amplifier
microphone, 12 ... control voltage

[Figure 5]

10 ... reverse bias, 11 ... modulated signal, 12 ...
control voltage, 13 ... forward bias
negative resistance circuit

[Figure 6]

10 ... reverse bias, 11 ... modulated signal, 12 ...
control voltage, 13 ... forward bias

negative resistance circuit
output

[Figure 7]

Frequency shift

B (conventional circuit)

A (circuit shown in Fig. 6)

control voltage

* * * * *

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